RM-14S

Radiation Monitor

OBSOLETE COPY
DO NOT REMOVE FROM SALES

Eberline *A subsidiary of*
Thermo Instrument
Systems Inc.
P. O. Box 2108
Santa Fe, New Mexico 87504-2108
(505) 471-3232 TWX: 910-985-0678

List | Repair Calibration

EFFECTIVE January 1, 1991
Prices are F.O.B. Santa Fe, New Mexico
Subject to change without notice
Terms: ¾ of 1% 10, net 30 days
Minimum order $40.00

The prices quoted herein do not include state, gross receipts, or local sales tax. The tax will be added as a separate item in the event that the transaction is determined to be taxable.

Eberline *A subsidiary of* ***Thermo Instrument*** *Systems Inc.*

P.O. Box 2108
Santa Fe, New Mexico 87504-2108
(505) 471-3232 TLX: 66-0438 EIC SFE
FAX: (505) 473-9221

GENERAL INFORMATION

Instruments for repair or calibration should be packaged, marked, or otherwise prepared in accordance with good commercial practices and shipped F.O.B. destination freight prepaid to one of the Eberline facilities below.

Repair and Calibration Facilities

Eberline Instrument Corporation
504 Airport Road
Santa Fe, NM 87504-2108
Attn: Western Service Center
(505) 471-3232
1-800-274-4212

Eberline Instrument Corporation
312 Miami Street
West Columbia, SC 29169
Attn: Eastern Service Center
(803) 822-8843
1-800-234-4212

Normal turn-around time for repair (Eberline instruments) is fifteen working days.

Normal turn-around time for calibration (Eberline instruments) is seven working days.

Prices (Subject to change without notice)

Certified calibration (Eberline portable instruments)(2 points/range)	
Unit and one probe	$90.00
Second probe	45.00
Third or fourth probe (Limited to 4 probes per instrument)	25.00
Certified calibration (other manufacturer's portable instruments)	90.00
ALPHA-3, ALPHA-5, AMS-3, HFM's, Portal Monitors, RM-22, SAM-2, WLM-1A, ESP-2 6112B, 6112D (certified calibration)	145.00
RGM-2 (certified calibration)	405.00
RGM-3 (certified calibration)	235.00
As found readings on any of the above, a charge of 50% of calibration rate shall be made.	
Calibrate "non-removeable" contaminated instruments	QUOTE
Services Contracts (Eberline equipment)	QUOTE
Technical Specification writing and Consultation	QUOTE
Service Engineer at Customers Site	$880.00/day plus expenses at cost +10% adm.
-Over 8 hours or Saturday and Sunday	165.00/hr
-Eberline Holidays	220.00/hr
Consulting	925.00/day
Repair rate (plus calibration and parts at list price)	85.00/hr
Repair "non-removeable" contaminated instruments	95.00/hr
Expediting Fee	50.00/ instrument
Accredited secondary standards laboratory calibration (Cs^{137} and Co^{60} photon)	QUOTE

Note: Repair and Calibration time on non-Eberline instruments is subject to availability of parts and literature for the specific instrument.

Repair or Calibration Warranty

Eberline warrants to replace or repair, at its option, any repaired products or replaced parts thereof (excluding tubes, crystals, batteries and normal consumables) which are found defective in material or workmanship within ninety (90) days from date of repair or the balance of the new purchase warranty, whichever occurs later. Instruments calibrated by Eberline are warranted to be within specified limits at time of shipment. In the event of calibration error, Eberline will again calibrate the instrument without charge to the instrument owner. The aforesaid warranty does not cover life-end failure of components and will be voided if repair has been attempted by other than seller's authorized personnel. In no event shall Eberline be liable for consequential or special damages, transportation, installation, adjustment, work done by customer or other expenses which may arise in connection with such defective product or parts.

Exclusion of Warranties and Limitation of Liability

The foregoing warranty is expressly made in lieu of any and all other warranties express or implied including the warranties of merchantability and fitness for a particular purpose. Under no circumstances shall seller be liable for any indirect, special, incidental, or consequential damages to customer or to any third party.

TABLE OF CONTENTS

Section Page

I GENERAL

Introduction 1-1
Purpose and Description 1-1
Features 1-1
Specifications 1-1

II OPERATION

Front Panel Controls 2-1
Indicators 2-1
Internal Controls 2-1
Preparations 2-2
Instrument Operation 2-3

III THEORY OF OPERATION

General 3-1
Functional Theory 3-1
Operational Theory 3-1

IV MAINTENANCE

Disassembly 4-1
Preventive Maintenance 4-1
Calibration Aids 4-1
General Calibration 4-1
Calibration with a Detector 4-2
Troubleshooting 4-6

V PARTS LIST 5-1

VI DIAGRAMS 6-1

VII DETECTORS AND ACCESSORIES

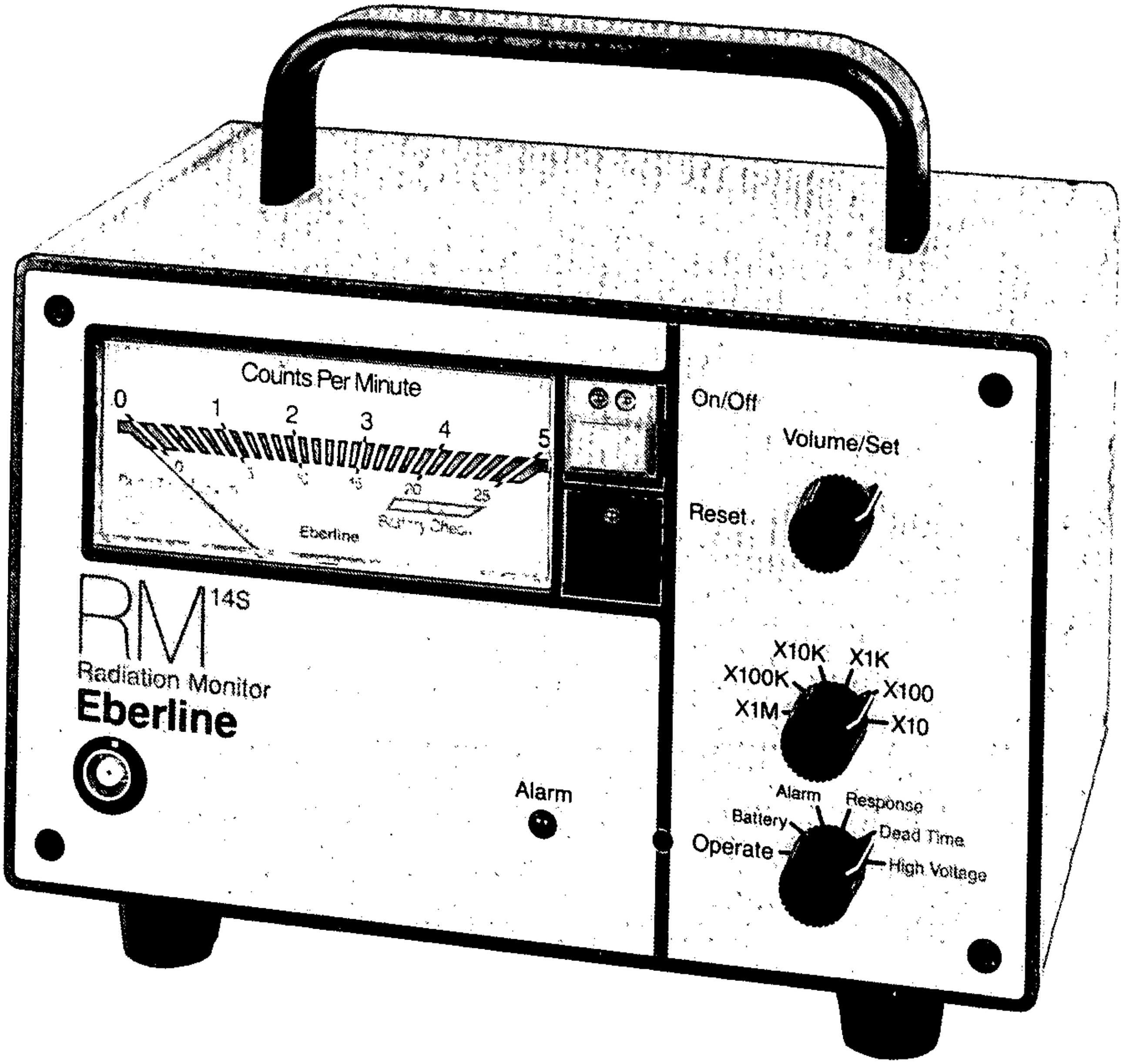
Options 7-1
Detectors 7-2

LIST OF ILLUSTRATIONS

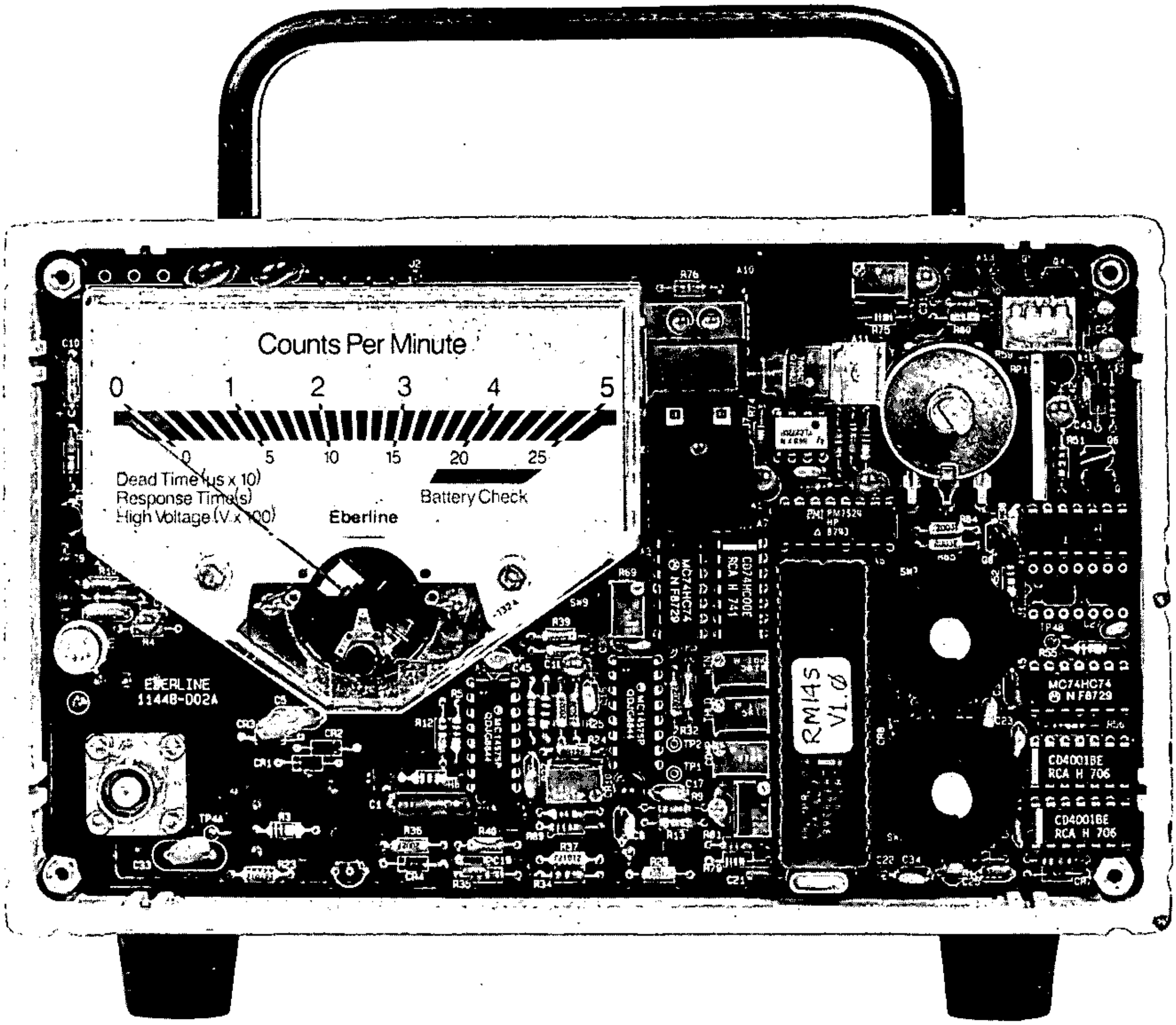
Figure		Page
1-1	Model RM-14S	iii
1-2	Model RM-14S Internals	iv
3-1	RM-14S Block Diagram	3-6
4-1	Typical Plateau Curve	4-3
4-2	Typical PHA Operating Curves	4-6
6-1	Component Layout, RM-14S Circuit Board	6-1
6-2	Schematic	6-2
6-3	Wiring Diagram	6-4

LIST OF TABLES

Table		Page
2-1	RM-14S Indications	2-5
4-1	Troubleshooting Guide	4-7
7-1	Detector Information	7-2



RM14S.MAN/Revision/August 1991


Counts Per Minute
0
1
2
3
4
5
0
5
10
15
20
25
Dead Time (µs x 10)
Response Time(s)
High Voltage (V x 100)
Eberline
Battery Check
EBERLINE
1144B-D02A
RM14S
V1.0
MC74HC74
CD4001BE
RCA H 706

SECTION 1
GENERAL

A. INTRODUCTION

Congratulations on your purchase of the Eberline RM-14S. The RM-14S exemplifies the continuing effort by Eberline to produce enhanced capability replacements for its instrument line, while maintaining the quality and cost effectiveness that Eberline is known for.

B. PURPOSE AND DESCRIPTION

The RM-14S is a new generation benchtop radiation monitor intended primarily for hand frisking applications. Its advanced features and compatibility with numerous detector probes make it a useful instrument for many other applications including low cost area monitors. The RM-14S is packaged in a rugged extruded aluminum housing which encloses the single printed circuit board, speaker, and battery. It is a microcomputer-controlled instrument which utilizes the time proven user interface techniques of an analog meter for data presentation and a potentiometer and rotary switches for instrument control. User definable parameters such as alarm setting, dead time, and response time are retained during power-off conditions.

The controls are all located on the front of the instrument with an On/Off pushbutton switch, a Reset switch, a six position range switch, a six position mode switch, and a speaker Volume/Set potentiometer. The meter scale is linear with an upper scale range from zero to five (0-5) cpm, and a lower scale range from zero to twenty-five (0-25) which is used for parameter display and adjustment. A MHV connector for detector attachment, power-on lights, a reset light, and a red Alarm light are also present on the front panel. The high voltage adjustment potentiometer is accessible through a small hole in the front panel.

C. FEATURES

- Dead Time Corrections
- Background Subtraction
- Detector Saturation Sensing
- Variable Detector High Voltage
- Variable Alarm Setpoint
- Variable Response Time
- Variable Speaker Volume
- Battery Backup
- Single Channel PHA
- Optional Alarm Relay Output
- Optional Probe Holders
- High Visibility Alarm Light
- Analog Meter Scale
- Six Decade Range Switch
- Built-in 10 mV Pulse Generator
- Internal Connector for Computerized Calibration

D. SPECIFICATIONS

Scale Length: 3.5 inches (8.9 cm)

Scale Marking: upper scale (black) -- 0 to 5 cpm; lower scale (red) -- 0 to 25, multi-use

Display Units: Counts Per Minute

Range: Switch controlled multipliers of X10, X100, X1K, X10K, X100K, and X1M, yielding 50; 500; 5K; 50K; 500K; 5M counts per minute full scale.

Mode:

Switch controlled instrument modes.

Operate: Meter displays count rate.

Battery: Battery [charge] level displayed. Calibration changes less than 10% within battery range limits on meter.

Alarm: 0 to 100% of full scale or disabled

Response: 1 to 25 seconds to 90% of reading

Dead Time: 5 to 250 μs, or disabled

High Voltage: 300 V to 2500 V (100M ohm load)

Linearity: Within ±10% of nominal, typically within ±5%.

Operating Temperature Range: -22•F to +140•F (-30•C to +60•C)

AC Power: 105-125 V, 50-60 Hz at 0.1A (220 V optional)

Battery:

Type: 6 Volt, 900 mA-hour Gel-type battery continuously charged with instrument plugged into line.

Charge Voltage: 6.80 V, Approximately 16 hours to full charge from full discharge with instrument turned off.

Shelf Life: Parameters are retained for more than 6 months.

Operational Backup: Operation on battery backup for a minimum of 8 hours, non-alarmed at full volume.

Detector Connector: MHV

Weight: 5.3 lbs. (2.4 kg)

Dimensions: 7.75 in. Wide x 7.00 in. High x 6.00 in. Deep (19.7 cm x 17.8 cm x 15.2 cm)

SECTION II
OPERATION

A. FRONT PANEL CONTROLS

Operation of the RM-14S is simple and intuitive. The display and controls are similar, if not identical to those used in traditional frisker units.

1. On/Off

The On/Off pushbutton switch turns the unit on or off. The switch has two built-in LEDs: green for indicating that the unit is line powered, and yellow for indicating that the battery is the power source for the instrument.

2. Reset

The Reset pushbutton switch is used to reset the meter reading to zero thereby clearing an alarm. It is also used to allow the setting of parameters, such as the alarm level and dead time, and for displaying the actual (gross) count rate while a background update is in progress.

3. Volume/Set

The Volume/Set potentiometer is used to vary the speaker volume and to adjust the parameters of alarm level, response time, and dead time.

4. Mode

The mode rotary switch is used to select each of six possible meter displays. The selections are: Operate (the current net count rate), Battery, Alarm, Response, Dead Time, and High Voltage.

5. Range

The range rotary switch is used to select the meter scaling multiplier for displaying counts-per-minute data in the Operate mode. The scaling multiplier of X10, X100, X1K, X10K, X100K, and X1M must be multiplied by the meter reading to obtain the proper count rate.

B. INDICATORS

On the front face of the RM-14S are several light emitting diode (LED) indicators which the processor uses to flag a number of different status conditions. Table 2-1 lists the LED states and the corresponding instrument status.

C. INTERNAL CONTROLS

All internal controls are accessed by removing the front panel except for the high voltage potentiometer which can be accessed through a small access hole in the front panel.

1. DIP Switches

A four-switch package is located in the upper right hand corner of the printed circuit board. These configuration switches are used to enable or disable several features. A switch number appears above each switch and the Open position is indicated below the switches. To Open a switch, use a pencil or some other pointed instrument and press the lower dot on the switch. When Open, the lower part of the toggle will be flush with the switch face. To Close a switch, press the upper dot. When Closed, the upper part of the toggle will be flush with the switch face.

Switch 1 (Lock), when closed, locks out the ability to change the alarm level, response time, or dead time. Opening the switch allows parameters to be changed.

Switch 2 (Latch), when closed, causes alarms to latch in the active state until the reading is reset. When in the open position, active alarms will be cleared automatically whenever the count rate drops below the alarm setting.

Switch 3 (Defaults), when closed, forces default parameters to be loaded for the alarm, response, and dead time settings. In addition, the high voltage reading will be flagged as "unknown" and a calibration value of 4.00 will be output to the meter. The switch closure produces the same effect as unplugging the unit and removing the battery fuse. Switch 3 MUST be open for the unit to be operational.

Switch 4 (Bkg Sub), when closed, causes a background reading to be taken. Reopening the switch causes the reading to be saved for the purpose of subtracting that reading from the gross count rate measurement. NOTE: Once the switch is closed, the meter will read zero (the net count rate) unless the Reset switch is pressed. This action will light the green Reset LED and cause the gross count rate to be displayed. Pressing the Reset again will turn the green LED off and return the display mode to net count rate. Note that each time the Reset switch is pressed, the meter reading will be reset and will require the normal response time before an accurate reading can be assured. RM-14S units with an external background subtraction switch may view gross count rate readings in this same manner, provided the switch is closed.

2. PHA/Gross

The PHA/Gross select switch (SW9) enables or disables the single channel analyzer. With the switch set to P, only detector pulses of amplitude greater than the threshold setting but less than the window setting will be counted. With the switch set to G, all pulses greater than the threshold setting will be counted.

3. Gain

The Gain potentiometer (R27) adjusts the amplifier's gain. Increase the gain by turning the potentiometer clockwise.

4. Threshold

The Thld potentiometer (R29) adjusts the discriminator threshold level. Lower the threshold by turning the potentiometer counter clockwise.

5. Window

The Win potentiometer (R30) adjusts the PHA window width. Increase the window by turning the potentiometer clockwise.

6. HV Adjustment

The HV potentiometer (R14) adjusts the high voltage level. The high voltage is adjustable from approximately 300 volts to 2500 volts. Turn the potentiometer clockwise to increase high voltage. If the unit is in High Voltage mode, the high voltage will be displayed as it is adjusted. When decreasing high voltage, both the meter response and the actual high voltage will lag the counter clockwise adjustment. Due to electrical characteristics, the rate at which the high voltage can be decreased will be slower than the rate at which it can be increased.

7. Meter Calibrate

The Meter potentiometer (R69) calibrates the meter to display count rates correctly. Calibrate the meter by closing the Defaults switch (SW3) and adjusting the potentiometer until the meter reads exactly 4.00. The switch should then be set to 'open'.

WARNING

Meter calibration will cause instrument configuration parameters to be lost when the Defaults switch is closed. See Section II.E.4.

8. Comparator Calibrate

The Comp potentiometer (R68) calibrates the comparator circuit which allows the meter to display the high voltage level correctly. Calibrate this potentiometer after setting the Meter potentiometer and disconnecting the detector, by setting the high voltage to 2000 volts (with probe disconnected) and adjusting the potentiometer until the meter agrees with the 2000 volt setting. Once calibrated, re-adjust the high voltage setting to match the detector probe to be used.

9. Charge Level

The Charge potentiometer (R67) provides for the adjustment of the battery charge voltage. For a fully charged battery, the nominal charge voltage is 6.80 volts (measured at the anode of the alarm LED (CR10), referenced to ground). The charge voltage will drop to approximately 6.5 volts when the unit is turned off.

D. PREPARATIONS

Before turning the unit on, plug the AC cord into 115 V, 60 Hz line (220 V, 50 Hz for instruments jumpered for the 220 V option.)

WARNING

If the high voltage setting is unknown, the detector should remain disconnected until the high voltage is matched to the detector.

Select the Operate mode.

E. INSTRUMENT OPERATION

1. Startup

Turn the instrument on by depressing the On/Off pushbutton. The green AC on LED should light. If the green Reset LED is blinking twice a second, then the memory has been reset and the instrument is using default settings for alarm, response time, and dead time. Setting any one of these three parameters will stop the blinking (see Section II.E.4). A much slower frequency blink (about once every five seconds) indicates the instrument is configured for background subtraction and is displaying net counts.

NOTE

Holding the Reset switch down while turning the unit On will cause a sequence of tones to be generated. These tones indicate the program firmware version of the instrument (e.g. Ver. 1.1 would produce a long tone followed by a short tone). The version tone sequence will repeat as long as the Reset switch is held down.

2. Operation Check

Set the mode to Battery and verify that the meter reads in the red 'Battery' zone indicating the battery charge voltage. Unplug the AC cord and verify the actual battery voltage. A reading near the lower end of the zone indicates the battery is almost discharged and the unit should be plugged into AC. A low battery will take about 16 hours for a full charge.

Using a digital voltmeter and high voltage probe, set the mode to High Voltage and verify the meter displays the correct high voltage setting (± 5%). If the meter reading is off, see Section IV.D on meter calibration. Set the mode back to Operate.

Adjust the speaker volume to a comfortable setting and set the range to X10. Place a check source next to the detector so that an up scale reading is achieved. Adjust the range until the reading is on scale.

Push the Reset switch and note the reading will drop abruptly, then return to its previous position as Reset is released. The response time may be adjusted to provide the best compromise between the response to sudden changes and the damping of statistical fluctuations.

Test the alarm by setting the alarm setpoint below the current reading. Return to operate mode and an alarm should occur. While in an alarmed condition, the Alarm LED will be lit and the speaker alarm tone of 1000 Hz will sound. Push the Reset switch and the reading will be zeroed, silencing the alarm. As the reading again exceeds the setpoint, the alarm will be re-triggered.

Move the check source away from the detector. The alarm should be cleared automatically as the reading drops below the alarm setting. If it does not, the internal Latch switch (SW2) is set preventing alarms from being cleared except by an operator reset.

3. Reading the Meter

The meter face contains two scales: one black 0 to 5 scale used for count rate readings in counts per minute, and a red 0 to 25 scale which is used for response time, dead time and high voltage readings. In addition, a red battery zone is also present which indicates the voltage region where the battery will provide reliable instrument operation. In order to interpret the count rate correctly, the values on the black scale must be multiplied by the proper factor. In the Operate mode, the multiplier of 10, 100, 1000, 10000, 100000 or 1000000, is determined from the selected range. Therefore, a reading of 3.2 on the X100 range should be interpreted to mean 3.2 times 100, or 320 counts per minute. For the Response, Dead Time, and High Voltage modes, the multipliers and units of measurement are printed on the meter face: response time is in seconds on the red scale and requires no multiplier; dead time is in microseconds and a multiplier of 10 must be used; high voltage is in volts and a multiplier of 100 must be used. In the Alarm mode, the setting is defined by a position on the meter and uses the multiplier for the range selected. The alarm setting remains at the same meter position when changing ranges.

4. Setting Parameters

During the time the instrument is turned off, power to the processor is maintained so that the user defined parameters are not lost. These parameters consist of the alarm setting, response time, dead time, most recent high voltage value, and the most recent background subtraction value. Should any of these parameters be corrupted, for example by loss of battery power, the RM-14S will sense the condition, restore default parameters, and indicate that it is out of calibration by a blinking Reset LED. While in Operate mode, the LED will blink several times each second until new calibration parameters are set (an infrequent blinking indicates background subtraction is in effect and should not be confused with the blinking due to the usage of default parameters).

The following default parameters are restored by the program.

Alarm Level	DISABLED(>F.S.)
Response Time	2 seconds
Dead Time	DISABLED (0μs)
High Voltage	UNKNOWN
Background Subtraction	DISABLED

Although the high voltage setting is defined by a hardware adjustment and is not alterable through the program, the high voltage value is measured whenever the unit is in High Voltage mode and recorded as soon as the mode is changed. New background subtraction values are recorded continuously as long as the Bkg Sub switch (SW4) is closed.

The procedure for defining the alarm, response time and dead time parameters may be described as follows:

a. Set the mode switch to the position of the parameter to be changed. The meter will display the value of the current setting.

b. Press the Reset switch. The green Reset LED should light indicating the parameter may now be adjusted. If the LED is not lit, it is possible that the internal Lock switch (SW1) has been closed preventing the alteration of parameters.

c. Watching the meter, adjust the Volume/Set knob to specify the new parameter value. Due to meter non-linearity, the value displayed may disagree slightly from the actual stored value.

NOTE

> **In the event that a parameter was inadvertently adjusted, the old parameter value may be restored by pressing the Reset switch again. The green LED will go out and the old value will again appear on the meter.**

d. Record the new setting by changing the position of the mode switch.

5. Dead Time Correction

The RM-14S is capable of correcting readings for losses due to detector and circuit dead time (i.e., the amount of time for the detector and detector circuitry to recover from a pulse before another pulse can be sensed). At high count rates the number of missed counts can be significant, but, by using a special algorithm which accounts for the missed counts, the RM-14S will correct the reading. Calibration of the dead time parameter is discussed in the Maintenance Section 4.E, Calibration with a Detector. Because dead time losses are only significant at higher count rates, the RM-14S will not correct for dead time on the lowest two ranges (i.e., the X10 and X100 ranges).

6. Using Background Subtraction

The internal Bkg Sub configuration switch controls whether the RM-14S is in the measure background mode or in the normal operate mode. The printed circuit board has provisions for a connector so that this switch can be remoted by the customer. When this switch is in the measure background position (Closed), the meter reads zero regardless of the count rate. The gross and background count rates are being measured simultaneously, hence the displayed net count rate is zero. The value of the background count rate can be viewed in this instance by depressing the Reset switch. When the Bkg Sub switch is moved to the normal (Open) position, the most recent value of the background is used in all subsequent net count rate calculations.

The instrument response time must be considered when performing background updates and/or viewing the background value. The same response time is used for both background updates and normal operation. Insufficient allowance for response time will result in inaccurate background measurements.

As a result, care must be taken to allow ample time for the instrument to respond to changes in count rate before the Bkg Sub switch can be opened saving a new background reading. As is the case with non-background measurements, pressing the Reset switch (to enter or exit the background view mode), or changing the range will cause the reading to be zeroed and at least two 'response times' must be allowed before saving a new value. This requirement is easily overlooked since, in the 'net counts' mode, the meter will not give a visual indication as the instrument responds to the new count rate level.

7. Upscale Readings

In the event a count rate is measured that is too high to be displayed on the current range setting, the meter will indicate a value that is above the end of the meter scale. When this occurs, switch to the next higher range to bring the reading on scale.

8. The Overrange Condition

An overrange condition occurs when the RM-14S records a high count rate requiring excessively large compensation for dead time. When this condition is met, the alarm LED will blink rapidly in conjunction with an alarm tone. Once the unit has entered the overrange condition, it can only be cleared by turning the instrument Off, then back On. Because an overrange condition is only necessary when dead time correction is being applied, the RM-14S will not overrange when the dead time is set to zero, or when the range is set to X10 or X100 (ranges which do not use dead time correction).

NO.	INDICATOR	STATE	MODE	CAUSE
1.	Green AC On	ON	ALL	Instrument power is being supplied from 120 Vac line.
2.	Yellow Battery	ON	ALL	Instrument power is being supplied from the battery.
3.	Green Reset	blinks every 1/2 sec	Operate	Instrument is using default parameters and must be recalibrated.
		blinks every 5 sec	Operate	Background subtraction is enabled and meter is displaying net counts.
		ON for approx 5 sec	Startup only	Background subtraction is enabled and meter is displaying the subtraction value while LED is lit.
		ON	Alarm, Response, or Dead Time	A parameter is being changed. Set new value with Volume/Set then change mode, or restore old value pressing Reset.
		ON	Operate with Bkg Sub	While updating background, the Reset was pressed. Meter is displaying gross count rate. Press again to clear condition and wait 2 response times.
4.	Red Alarm	ON	Operate	Instrument is in an alarmed condition. Clear alarm with a Reset.
		blinks every 1/2 sec	Operate	Instrument is in count rate overrange condition. Count rate is too high for dead time correction. Turn unit Off then back On to clear the condition.
		NOTE:	Speaker alarm tone will sound whenever the red Alarm LED is lit.	
5.	Meter	above scale	Operate	Range setting is too low for reading. Increase range.
		above scale	Alarm	Alarm setting is set to maximum (disabled).
		reads 4.00	ALL	Defaults switch (SW3) is set forcing the meter calibration output.

Table 2-1, RM-14S Indications

SECTION III
THEORY OF OPERATION

A. GENERAL

The RM-14S employs microprocessor technology together with conventional controls to produce a digital instrument with the look and feel of an analog design. The design objective of analog 'ease of use' combined with microprocessor 'flexibility and power' have been fulfilled in the RM-14S. The variable high voltage and adjustable dead time give the RM-14S the capability to be used with a variety of detectors, and over a large range of count rates.

B. FUNCTIONAL THEORY

Functional theory of the RM-14S can be broken into several functional subsections:

1. Detector

The detector is selected to optimize the accuracy of the reading for the radiation of interest. It provides the pulse signal to the electronics for counting. The pulse rate from the detector is proportional to the radiation field measured by the detector.

2. High Voltage Supply

The high voltage supply provides the bias voltage to the detector as required for proper operation. The high voltage is regulated to enhance operating stability and adjustable to provide the correct operating voltages for a large selection of detectors.

3. Amplifier/Discriminator

The amplifier is a linear, fixed-gain, multistage design. It amplifies the signal from the probe to a usable level at the amplifier output. The discriminator provides a signal on its output only if the signal from the amplifier exceeds the adjustable threshold. This, in turn, provides a means for counting only radiation signals and rejecting noise. In the case where Pulse-Height-Analysis (PHA) is selected, the signal must also fall within an amplitude window in order to be passed by the discriminator. This provides a means for counting only a specific range of signal amplitude which is proportional to the energy of detected radiation. The PHA operation allows the measurement of a specific energy window.

4. Speaker/Alarm

The speaker/alarm section provides an audible "click rate" from the speaker, which is equal to the output of the amplifier/discriminator. When the alarm is activated, the speaker emits a continuous 1000 Hz tone.

5. Controls

The controls section provides the means of setting how the instrument operates. Operator inputs are sensed by the microprocessor through the switches and potentiometers.

6. Outputs

The outputs section provide the indications to the operator of the state of the instrument. Visual indications of the instrument state are provided to the operator by LED indicators and the meter.

7. Microcomputer

The microcomputer section consists of the microcomputer and its clock, reset, and power-down circuitry. The microcomputer controls the instrument operation, the interface with the operator, the counting of detector pulses, the calculations on the data, and the display of the data to the operator in a usable format.

8. Power Supply and Battery Charging

The power supply and battery charging section regulates and provides power to the instrument from either a 115 volt line source or the battery. While operating on 115 volt line input, the battery charge circuitry provides the required charge voltage to the battery.

C. OPERATIONAL THEORY

1. Power Supply and Battery Charging

The RM-14S is supplied power from a 115 Vac (or optional 230 Vac) line source, and by a 6 volt DC 'Gel-Cell' type battery. During operation on the AC line source, the battery is being charged. When AC power is removed from the unit, power is supplied from the battery. Transformer (T2) and diode rectifier (A10) provide the unregulated 15 volt input to the battery charging regulator (A11). The 6 volt charging regulator is referenced above ground to produce a charge voltage of 6.75 volts on the battery (+VBAT). When AC power is removed, diode CR12 prevents feedback to ground from the battery through voltage divider R80/R66 and charge level reference R67.

Beyond the battery lie two 5 volt regulators (A13 and A16) which supply power to the processor and relay driver (+V1), and to the remaining components on the board (+V2). The +V1 supply is always present and maintains the memory in the processor during power-down mode (the processor is unpowered only when the line source is removed and the battery disconnected or the battery fuse removed). The +V2 supply is controlled by Q4, which is indirectly switched on/off by the processor power-down sequence. This causes the +V2 supply to be removed when the unit is turned off.

2. High Voltage Supply

Transistor Q2 and transformer T1 form an oscillator circuit. The voltage of the secondary of T1 is highly stepped up. CR1, CR2, CR3, CR4, and C5 form a voltage tripler circuit. R3, C2, and C3 help filter this voltage. R1 carries the high voltage to the detector while isolating the detector signal from the high voltage filter.

R2 is a very high impedance divider used in a feedback loop to control and regulate the high voltage output. A1 pin 3 is the input to an amplifier, which is used as a low output impedance follower of the divider signal.

A1 pin 1 drives amplifier input A1 pin 6, while the input reference is set by the HV potentiometer (R14). The output of this stage drives Q1, which controls the level of oscillation of the high voltage circuit, thereby completing the feedback loop. A1 pin 1 also drives a comparator (A1 pin 11), which is used by the processor to match the meter output to high voltage, thereby displaying the high voltage on the meter.

3. Amplifier

Transistor Q3 and the two operational amplifiers of A2 form the RM-14S amplifier section. Resistors R38 and R39 set a direct-current reference for the operational amplifiers and a feedback loop through R40, while R36 provides a direct-current bias for the entire amplifier. The gain potentiometer (R27) is normally set at maximum gain (fully clockwise) except when the instrument is required to be less sensitive than is possible using Thld potentiometer (R29) alone.

4. Discriminator

The amplifier output (A2 pin 7) goes through C17 to comparator input pins 12 and 14 of A2 and is direct-current biased by the wiper of the Thld setting (R29). The threshold comparator reference input (A2 pin 11) is biased to 2.0 volts yielding a threshold range of 1.0 volt. The threshold comparator will then pass any amplifier pulses of amplitude greater than the 2.0 volts minus the threshold bias. The window comparator reference input (A2 pin 15) is direct-current biased between 2.0 and 3.0 volts by the Win potentiometer

(R30) wiper. The window comparator will pass any amplifier pulses of amplitude greater than the window reference minus the amplifier output bias (a range of from 0.0 to 2.0 volts).

The threshold comparator output (A2 pin 10) passes through one propagation delay (A4) and clocks A3 pin 11, a D-type flip-flop, and three further propagation delays (A4 gates 2, 3, and 4). The output of the fourth delay (A4 pin 8) clears the output of the flip-flop yielding a very narrow output pulse (A3 pin 9) of about 60 nanoseconds.

When PHA counting is selected by setting SW9 to P, the output of the window comparator clocks A3 pin 3 and generates a premature CLEAR of the output A3 pin 9, thereby preventing a pulse from being passed.

In addition to the narrow output pulse (A3 pin 9), the discriminator provides a second, divide-by-two, output from A5 pin 6 which drives the processor counter.

5. Speaker/Alarm

Two sections of A8 (pins 8, 9, 10, and 11, 12, 13) form a free running oscillator of about 1 kHz. This oscillator drives the speaker. The other two sections make up a monostable trigger which turns on the oscillator for about 2 milliseconds each time a detector pulse arrives. Because the discriminator output pulse is quite narrow, the signal is integrated by R54 and C23 to provide enough active time on the input A8 pin 6. The speaker oscillator may be disabled from the processor by setting the port P3.5 output bit high. The processor may also force a continuous alarm tone by writing port P0.6 low, thereby latching the active low monostable output.

Speaker volume is controlled by Volume/Set potentiometer R59, the wiper of which drives the base of Q8 regulating speaker drive. The volume controls are bypassed and the speaker operates at full volume whenever the alarm (port P0.6 bit) is triggered, saturating Q6.

6. Controls/Outputs

The Volume/Set potentiometer, in addition to functioning as the speaker volume control, serves as a control for adjusting the meter reading while a parameter is being set by the operator. This is accomplished in an indirect manner. The wiper of R59 sources voltage divider R84-R85 which provides a variable voltage reference to comparator reference pin 15 of A1. The comparator input pin 14 of A1 is the meter output (A7 pin 1) amplified (A15 pins 5, 6, 7) to a signal in the range 0.0 to 2.5 volts, and provides the means for the processor to match the meter reading to the Volume/Set position. The processor accomplishes this by ramping up the D/A (A7) output until comparator output A1 pin 16 goes high. The D/A is then ramped down until the comparator output goes low. Using this algorithm, the processor is able to track the adjustment of the Volume/Set potentiometer.

The mode and range switches are six position break-before-make type with a wiper that shorts between adjacent pins. Three processor port bits are used to sample the position of each switch. The algorithm used to determine switch position incorporates configuring some bits as outputs and writing them high, while reading the other bits as inputs.

The Reset switch is a simple momentary pushbutton which, when depressed, pulls processor port bit P2.6 low. A green Reset LED is controlled by another processor output port bit (P0.7) which drives the open-collector output pin 12 of A14.

The On/Off switch is sampled via processor port bit P2.7, while the processor is running. When the bit is observed to go high, the processor executes the power-down sequence and shuts the instrument off. Two light emitting diodes provide indication of the power source from which the instrument is operating. The green AC On LED is sourced directly from the battery charge regulator (A11) output, while the yellow Battery LED is sourced by the +V1 supply but switched by open-collector output pin 10 of A14.

The meter is driven by writing an 8-bit value out processor port P1 to digital-to-analog converter A7. The D/A output to the meter is not amplifier driven. The current out is a function of the +V2 supply voltage and the code selected internal resistors. R69, the Meter potentiometer, is in parallel with the meter so that the full scale voltage drop of the meter does not vary. An amplifier scales the meter output voltage into the range 0.0 to 2.5 volts for use as a reference input into the high voltage and 'set' comparators (A1 pins 12 and 14). The meter output amplifier (A15 pin 7) is calibrated by the Comp potentiometer so that the high voltage reads correctly on the meter when the comparator output (A1 pin 10) is toggling.

The Alarm LED (CR10) is driven by the same open-collector output (A14 pin 11) that causes the speaker volume bypass to occur on alarms.

7. Microcomputer Circuitry

The microcomputer system consists of the processor (A6), clock circuitry (X1, C21, C22), the power-down circuitry (R81, R52, Q5, SW5), and the power-up section (Q4, C24, R51, CR5, CR6, R43).

a. Clock

The crystal oscillator (X1, C21, C22) provides the clock input to the processor pins 18 and 19. The frequency of 7.3728 MHz provides the means to generate the 9600 bit per second (baud) communications rate at the processor serial output pin, as well as providing a sufficient time base for other program requirements.

b. Power Down

The power-down-up circuitry works as follows:

Whenever On/Off switch SW5 closure is sensed, the processor disables interrupts and writes all port bits to the power off state (low). Next, the processor calculates a checksum on internal memory so that a loss of processor power (hence memory loss) can be determined on startup. SW5 is then sampled to wait for switch release, at which point the power-down is performed by clearing port bit P3.6 (PWR_1) and setting P3.7 (PWR_2).

Setting PWR_2 causes a clear of all open-collector outputs of A14.

Q4 is then shut off as A14 pin 9 goes to a high-impedance state, removing power from regulator A16, hence the +V2 bus. This powers down all devices on the board with the exception of the processor and the A14 driver (although its outputs are disabled).

The processor enters a power-down mode to reduce current requirements during the Off state. A processor RESET is required to bring the processor out of the power-down mode.

c. Power Up

The power-up commences with the closure of On/Off switch SW5 as follows:

Closure of SW5 grounds the CLR and /OE pins of A14, which enables the open-collector output on pin 9.

Q4 is turned on when the open-collector output, pin 9 of A14, becomes active. This enables power to 5 volt regulator A16 and brings up the +V2 supply.

Meanwhile, C42 passes a spike caused by Q4 being switched on, through R43 and CR5 and generates a processor RESET on pin 9 of A6. The RESET brings the processor out of power-down mode and program execution begins.

As the processor is reset, a logic 1 is written to all port pins. The 1 on port pin P3.6 turns on Q5 and assures the continuance of the +V2 supply after the power switch is released.

8. Program Theory

a. General

The RM-14S program is designed to reduce processor current requirements by executing a small fraction of the time, and spending the remainder in a power saving 'idle mode'. This is accomplished by executing most program instructions under a timer interrupt which occurs several times a second. On termination of the interrupt, the 'idle mode' is entered. Execution of instructions will then resume only after the specified time defined by the timer preset. Performance analysis has shown that the processor is executing instructions only 2% of the time available.

b. Startup

The program performs one of two different startup sequences depending on the results of a checksum test on internal memory. If the checksum test verifies that memory contents have not been altered during power-down, a 'warm-start' sequence is performed. Otherwise, memory contents are assumed to be destroyed and a 'cold start' sequence is performed.

During a cold start all internal memory locations are cleared and a set of default values loaded to define the instrument operation parameters. A cold start is followed by a warm start.

During a warm start, the I/O port bits are initialized as are the internal timer values, flag bits, and other internal registers.

c. Operate Mode

In Operate mode, the counts are read at the start of every timer interrupt. The timer is then reloaded, the counter zeroed, and both timer and counter restarted. The counts are adjusted for dead time, a weighted average count rate calculated, and any background value subtracted. The value is written to the D/A for display on the meter and any alarms or overrange conditions are then annunciated by turning the alarm on.

Timer durations are defined by the current range setting, and vary from 59 to 96 milliseconds in length.

d. Battery Mode

In Battery mode, as well as all other non-Operate modes, timer interrupts occur every 5 milliseconds. The D/A output is zeroed, then incremented each interrupt until the battery voltage comparator output toggles. The D/A value is then incremented or decremented as required by the state of the comparator. This produces a meter reading that is proportional to the battery/charge level.

e. Alarm Mode

In Alarm mode, the program writes the value of the current alarm setting to the D/A. Each interrupt the switches are tested for operator input. When the state of the reset switch is seen to change, the program writes the green Reset LED bit high, turning the LED on. In this adjust mode, the meter match algorithm described above is used to match the D/A output to reflect the value of the Volume/Set potentiometer. Once the mode setting is changed, the latest D/A value is saved as the new parameter value and the Reset LED is turned off.

f. Response Mode

The program treats the Response mode identically to the Alarm mode, by displaying the current dead time value, allowing it to be adjusted, and saving the new value.

g. Dead Time Mode

The program treats the Dead Time mode identically to the Alarm mode, by displaying the current dead time value, allowing it to be adjusted, and saving the new value.

h. High Voltage Mode

The High Voltage mode is treated similarly to the Battery mode, with the meter being matched to the input value of the high voltage comparator. On a change of mode switch position, the current D/A output value is saved to provide a record of the high voltage. The high voltage value is reported out the serial port on startup.

i. Serial Communications

The RM-14S program reports the current settings and status of the unit whenever the instrument is turned on. Thereafter, the status of the mode and range switches are reported each time the position is changed. If new values for alarm, dead time, or response time are defined, the values are reported after the mode is changed and the new value stored.

While in Operate mode, current data are reported every 256 timer interrupts. All messages are sent in ASCII format out the serial port at 9600 b/s, 8 data bits, no parity, and 1 stop bit.

During serial communications operations, the timer value is loaded with a value that provides for transmission at 9600 b/s. The detector pulse counter is not stopped during transmission and, after transmission ends, the count duration is adjusted accordingly.

j. Average Count Rate Determinations

The meter always displays the net count rate, i.e., the gross count rate (corrected for dead time losses) less the count rate stored as the background value. If background subtraction is not used, the stored background should be set to the default value of zero so that the net count rate is equal to the gross count rate. The RM-14S calculates the average count displayed on the meter using an algorithm which emulates the response of analog type instruments. It incorporates a weighted average with the weighting factor calculated such that the resulting time behavior of the expression exactly tracks that of an analog ratemeter circuit with a response time based on an RC time constant.

$$R_{new} = \frac{R_c + wR_{old}}{w + 1}$$

where:

R_{new} = The new average count rate
R_c = The count rate averaged over the current count interval
R_{old} = The average count rate from the previous calculation
w = The weighting factor

The weighting factor is calculated as:

$$w = \frac{1}{2^p - 1}$$

where:

$$p = 3.32 \frac{t_c}{t_r} .$$

t_c = The current counting interval in seconds (depends on range setting)

= 0.0960 on 10 range
= 0.0600 on X100 range
= 0.0750 on X1K range
= 0.0938 on X10K range
= 0.0586 on X100K range
= 0.0732 on X1M range

t_r = the response time in seconds

Response time is defined as the time it takes the meter reading (R_{new}) to go from 0 to 90% of the final value of a step change in the input count rate.

SECTION IV
MAINTENANCE

WARNING

The high voltage power supply is capable of producing over 2500 volts and the energy stored in the filter capacitors may produce a hazardous shock. Voltage bleeds down slowly when the instrument is turned off.

WARNING

Whenever the instrument is switched Off, power is removed from only a portion of the circuit. To completely remove all power sources, the AC power cord must be unplugged and the battery disconnected by removing the battery fuse.

CAUTION

The circuitry in the RM-14S employs CMOS technology and is subject to damage from electrostatic discharge with the front panel removed. All equipment and components must be grounded to the RM-14S chassis or circuit common before touching any components.

A. DISASSEMBLY

Maintenance and calibration simplicity has been built into the RM-14S. The front panel can be removed by pulling off the three 'press on' control knobs and removing the four mounting screws. This provides convenient access to the component side of the printed circuit board. Calibration, troubleshooting and repair are much easier to accomplish since the internal circuit board doesn't have to be removed in order to access test points or replace components. If access to the rear side of the board is necessary, the board assembly may be released by removing the four standoffs at the corners and lifting the board out.

B. PREVENTIVE MAINTENANCE

The RM-14S should be kept as clean and dry as possible. The battery should be replaced after approximately four years of use (a date code is usually present on the bottom face of the battery.) No other routine maintenance is required except for normal (owner specified) periodic recalibration.

C. CALIBRATION AIDS

The RM-14S has a built in pulser circuit which can, in many cases, eliminate the need for an external pulser. The pulser provides a 10 mV (±10%) pulse height at three fixed frequencies. The RM-14S also has an internal connector which provides a serial communications output port. This port can be connected to a printer, display terminal, or computer through an optional RS-232 converter and will provide status, setup information, and data in ASCII format. Status and setup information is transmitted at power up and any time a parameter or condition changes. This is very useful during checkout and calibration as various controls and switches can be tested with the result displayed or printed by the connected device. Data is transmitted at an approximate rate of once every 15 seconds. This can be used to minimize calibration errors due to meter interpretation and to automate calibration.

D. GENERAL CALIBRATION

1. Battery Charge Regulator

Connect an accurate voltmeter to the cathode of CR12 (or J2 pin 2), relative to circuit ground. Adjust the charge level potentiometer (R67) for a reading of 6.70 to 6.80 volts on the meter. Perform this calibration with the instrument turned On, the battery connected, and AC line power present.

2. Meter

WARNING

Meter calibration will cause instrument calibration parameters to be lost when the Default switch is closed.

Turn the instrument Off and adjust the mechanical meter zero until the meter reads zero. Set the Defaults switch (SW3) to Closed and turn the unit On (the meter should read in the upper half of the scale). Adjust the Meter potentiometer (R69) for a reading of 4.00 on the Counts Per Minute scale. Set the Defaults switch (SW3) to Open. The meter is now calibrated for rate meter readings.

3. High Voltage Display

Complete the standard meter calibration described in step 2 before performing high voltage display calibration. For this operation, use a very high impedance voltmeter (1000 Megohms or more). Disconnect the detector and measure the high voltage on the center conductor of the MHV connector. Adjust the high voltage level (R14) for a reading of 2000 volts on the voltmeter. Set the mode switch to High Voltage and adjust the Comp potentiometer (R68) until the RM-14S meter shows the correct reading of 2000 volts. Adjust the high voltage to a few other values across the meter face and compare the RM-14S reading to the external voltmeter. The agreement should be within 50 volts plus any inaccuracy of the external voltmeter.

E. CALIBRATION WITH A DETECTOR

1. General

The RM-14S is an extremely versatile instrument that can be used with a wide variety of detectors. The purpose of instrument calibration is to produce readings which accurately reflect the detected count rate.

Properly set up and calibrated, the instrument is inherently linear and accurate, a result of its microcomputer-based design. Usefulness of the instrument is only limited by the practicality of the detector for a specific application. For detector application information, see Table 7-1.

2. Input Sensitivity

Table 7-1 lists several Eberline detector models and gives typical calibration settings for each. Unless the application requires PHA, the input sensitivity can be set as shown since the sensitivity is not critical for gross counting mode. For detectors not listed, set the sensitivity to 10 mV.

For a fixed sensitivity of 10 mV, the internal RM-14S pulser signal may be used to calibrate the threshold. Connect a jumper between test points TP4A and TP4B and adjust the Thld level.

For all sensitivities between 5 and 15 mV, set the Gain control (R27) fully clockwise for maximum gain. Connect a calibrated pulse generator (Eberline minipulser Model MP-1 or MP-2, typical) to the detector connector and set the input sensitivity by adjusting the Thld control (R29).

If the input sensitivity is to be set at more than 15 mV (up to 50 mV maximum), a calibrated pulse generator (Eberline minipulser) or pulser and oscilloscope will be required. Connect the pulse generator to the detector connector and set the signal (negative) amplitude to the desired sensitivity level. Set the Thld control fully clockwise, then adjust the Gain control (R27) until the crossover point is located.

3. High Voltage Setting

WARNING

To prevent damage to the detector, the high voltage setting should be set to the nominal operating voltage or less (Ref. Section VII) before connecting the detector to the RM-14S. Check the setting by selecting the

High Voltage mode. (Make sure that calibration of the high voltage reading has been performed).

The bias (high voltage) operating point for a GM detector is fixed by its physical properties (i.e., size, counting gas, anode size, and fill pressure). Therefore, a check of its sensitivity, or efficiency, may preclude the plateau. It should be within ±20% of specified sensitivity at the specified operating voltage (see Section VII).

To run a plateau, connect the detector to the RM-14S with the cable to be used in operation. With the discriminator properly set, the plateau curve can be plotted. See Figure 4-1.

To plot a plateau select a response time of about 10 seconds. Expose the detector to the source of radiation. The exposure rate is not too important. Select the High Voltage mode and set the HV control (R14) for a low reading.

Select Operate mode again and set the range switch to the appropriate range and record the meter reading. Change to High Voltage mode again and increase the high voltage in 50- to 100-volt steps, recording the reading at each point. Allow enough time at each step for the reading to stabilize. Plot the plateau curve and set the high voltage accordingly.

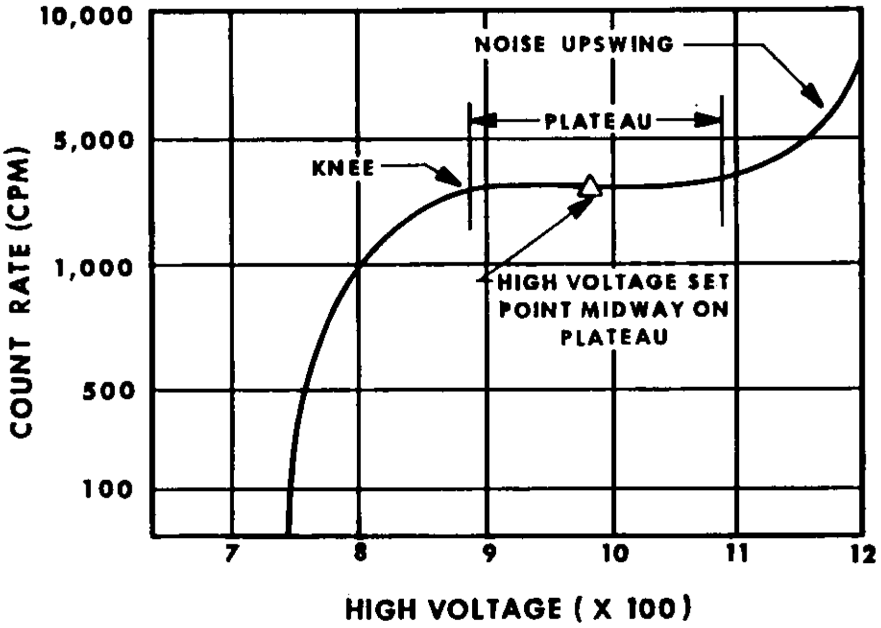


Figure 4-1. Typical Plateau Curve (11338-B25)

An alternate, less formal method of determining the plateau location, consists of the following. Connect the detector and expose it to the radiation source. Set the range switch to an appropriate multiplier position and slowly bring the high voltage up until a plateau region is found. Adjust the high voltage until the low end of the plateau is found. Switch to the High Voltage position and record the high voltage. Switch back to the multiplier position and carefully bring up the high voltage until the upper end of the plateau is found. Compare the two high voltage values and select an operating point in between.

4. Calibration Procedure for any Detector

a. Determine the detector sensitivity in cpm per rate unit (e.g. cpm/mR/h). Set the response time to 20 seconds and place the detector in a calibrated field of low enough strength to make dead time effects negligible. After approximately 50 seconds, the reading should have stabilized. Divide the reading by the field strength. The result is the detector sensitivity, which should be approximately equal to the table value.

b. Set the response time back to 5 seconds and expose the detector to a relatively high field where the dead time losses are significant. (Table 7-1 gives recommended high exposure rates for some standard Eberline detectors.) Based on the detector sensitivity determined in 4.a, calculate the expected count rate for the new field. Set the dead time so that the meter reads the expected count rate when the probe is placed in the new field. (The nominal dead times of some standard Eberline detectors, when used with the RM-14S, are also shown in table 7-1.).

NOTE

> **Dead time may be set to zero, or from 5 to 255 microseconds. All dead time values less than 5 microseconds will be set to zero, disabling dead time correction.**

c. Perform a linearity check at various exposure rates from a low rate up to where the overrange alarm is given. Overrange occurs at a precomputed count rate, based on the dead time setting. The RM-14S must be turned Off, the count rate reduced, and turned back On to reset the overrange alarm. If desired, adjust the dead time value slightly to average out points where the meter reading is above and below the nominal value.

d. If radiation exposures sufficiently high to do steps b and c above are not available, set the dead time to the nominal value given for the detector.

e. Calibration Summary

1) Set the input sensitivity with the Thld and Gain controls.

2) Set the high voltage with the HV control.

3) Determine detector sensitivity at a low count rate.

4) Determine the dead time at a high exposure rate.

5. Calibration with PHA

To utilize the pulse-height analyzer (PHA) function, the amplitude of the detector pulses must be proportional to the energy of the radiation and must vary with the high voltage applied.

A review of the PHA circuit description and terms used in the "Theory of Operation" section may be helpful. The adjustment of the window width, relative to the threshold setting, is always a compromise. Refer to the curves in Figure 4-2. In each case, the narrower window results in a sharper peak (better exclusion of adjacent energies), but the count rate is lower and the peak may be harder to find. Experimentation using the particular detector and a check source of the isotope of interest will help select the best percent window for your application. In general, a window between 25 percent and 100 percent of the threshold level is reasonable.

The following are examples of various methods of setting the threshold and window controls.

a. Method 1. No test equipment required.

1) Set the Gain control fully clockwise for maximum gain.

2) Set the Thld control fully clockwise for least sensitivity. This will result in about 6mV input sensitivity.

3) Set the Win control fully clockwise for widest window. This will set the window about 6 mV wide, a 100 percent window. (For a 50 percent window, set the Win control midway between the end points [about 12 turns of the 25 turn pot].)

4) Set the PHA/Gross switch to P.

5) Expose the detector to the isotope of interest and adjust the high voltage until the energy peak lies in the window, indicated by a decrease in reading when the high voltage is adjusted either way. Remove the source to verify that the proper peak was found.

6) Check the Gross G position. The reading will increase if energies above the window setting are present at the detector. Reset to P for PHA operation.

b. Method 2. Voltmeter method.

1) Set the Gain control fully clockwise for maximum gain.

2) Set the Thld control fully clockwise for least sensitivity.

3) Connect the reference lead of a voltmeter to the Ref test point TP3.

4) Measure the voltage at the Thld test point TP2. It will be approximately 1 V with respect to the reference lead.

5) Connect the voltmeter lead to the Win test point TP1. Adjust the Win control for a positive voltage equivalent to the percent window desired. For a 25 percent window, make this voltage one-quarter as large as that found in step 4, and so forth.

6) Set the PHA/Gross switch to P.

7) Expose the detector to the isotope of interest and adjust the high voltage until the energy peak is in the window. Remove the source to verify that the proper peak was found.

8) Check the PHA/Gross switch operation. Return to P for PHA operation.

c. Method 3. Pulser Usage

A calibrated pulser could have taken the place of the voltmeter in method 2 (immediately preceding). Instead of measuring the threshold and window voltages, the pulser, connected to the detector connector, could have been used to establish the desired signal levels and the Thld and Win control adjusted for crossover. The window would then have been at 50 percent (threshold 6, window width 3).

This next procedure uses the pulser to set up the PHA circuit to correspond to actual energy levels. Once set, a voltmeter can be used to select a different specific energy.

1) Connect the calibrated pulser (Eberline Minipulser, for example) to the detector connector.

2) Set the pulser for 10 mV output, between 2K to 20k cpm.

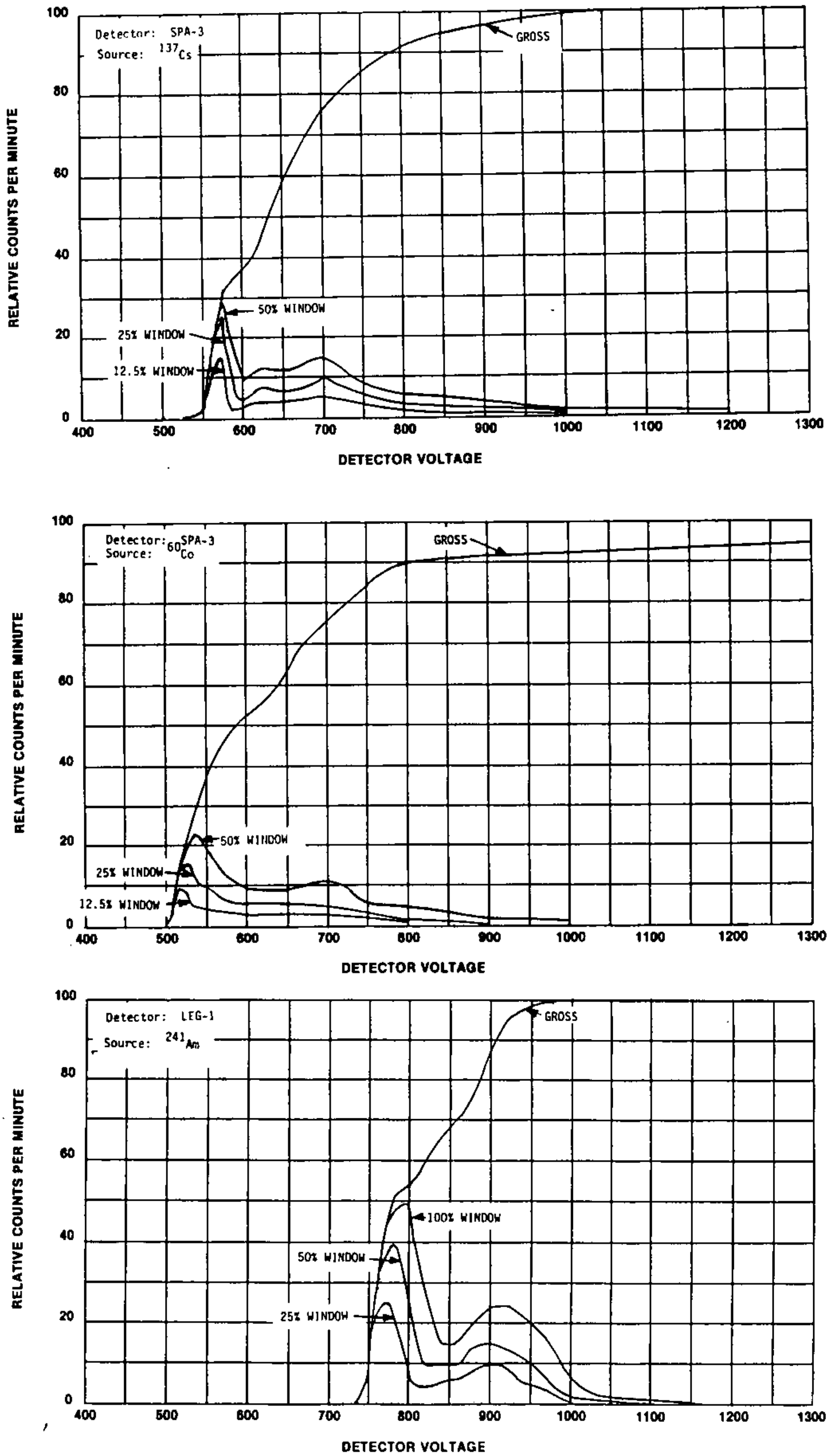


Figure 4-2. Typical PHA Operating Curves

5) Adjust the Gain control until the crossover point is located.

6) Set the PHA/Gross to P.

7) Set the pulser for 12 mV.

8) Adjust the Win control until crossover is located.

9) Set the pulser at 5.6 mV output.

10) Set the PHA/Gross switch to G.

11) Adjust the Thld control until the crossover point is located.

12) Remove the pulser and connect the detector to be used.

13) Select P.

14) Expose the detector to a ^{137}Cs source and adjust the high voltage until the cesium peak (660 keV) is in the window. Remove the source to help make sure the proper peak was found.

As now set up, the nominal span of the threshold and window controls is from zero to 1 MeV, corresponding to zero to one volt as measured on the Thld and Win test points TP2 and TP1, referenced to TP3. (For measurement points, see method 2 above.) A voltmeter can now be used to set new specific energies for the threshold and window widths. Remember, the peak is centered in the window, which is one-half a window width above the threshold setting.

If, in step 9 the pulser had been set at 2.3 mV instead of 5.6 mV, the nominal calibration would have been from zero to 2 MeV. An alternate method to obtain zero to 2 MeV is to use ^{60}Co (1.25 MeV, average of two peaks) instead of ^{137}Cs and set the pulser at 5.25 mV in step 9.

In all cases, where possible, the isotope of interest should be used to make the final adjustment to make sure the energy peaked in the window.

F. TROUBLESHOOTING

The primary troubleshooting aid is a thorough understanding of the circuit functions. Section III, "Theory of Operation"; Figure 3-1, the block diagram; and Figure 6-2, the schematic, are the primary aids to this understanding.

The following table provides some possible solutions to specific symptoms.

NO.	SYMPTOM	POSSIBLE FAULT	POSSIBLE SOLUTIONS
1	LED's come on but instrument will not respond to controls.	Processor inoperative Defaults switch is set Switched +5 V regulator bad	Check oscillator X1 Set SW3 Open Replace A16
2	Instrument totally dead, +V1 line is low	+5 V regulator is bad No AC line or battery source Heavy load on +V1 line	Replace A13 Check fuses Replace faulty component
3	Operates on battery only.	Bad power supply component component Isolation diode is bad	Replace faulty Replace CR12
4	No high voltage, or HV ADJ pot has no control over HV.	Bad HV oscillator Bad tripler diode Heavy load on HV	Replace Q2, T1 Replace CR1, CR2, or CR3 Check probe
5	High voltage output unstable.	High voltage leakage or component breakdown Clean MHV connector. Replace faulty component.	Check detector and detector cable. Clean HV components and circuit board.
6	Meter does not display high voltage correctly.	Meter not calibrated for HV	Perform high voltage calibration procedure
7	Meter displays count rate but no audible count rate indication.	Bad speaker oscillator Bad speaker drive component Bad speaker	Replace A8 Check Q6 and Q8 Replace speaker
8	Audible count rate but meter displays zero.	Bad divide-by-2 flip-flop Background subtraction enabled (Reset LED blinks approx. every 10 S) Incorrect range setting	Replace A5 Restore defaults and recalibrate, check SW4 Check range switch
9	Battery level reads low on meter when instrument is line powered.	Charge level is incorrect Slo-Blo type fuse is being used	Set battery charge level at 6.75 V Use non-resistive fuse
10	Battery level reads low when running off battery.	Slo-Blo type fuse is being used Bad or old battery (more than 4 years)	Use non-resistive fuse Replace battery

NO.	SYMPTOM	POSSIBLE FAULT	POSSIBLE SOLUTIONS
11	Instrument operates but will not turn off.	Bad power-down circuit component Bad On/Off switch Q5 shorted	Replace A14 Replace SW5 Replace Q5
12	Meter reads zero in all modes.	Bad D/A meter driver Meter miscalibrated Bad meter or meter connection	Replace A7 Check meter calibration Check meter terminals Replace meter
13	Meter reads 4.00 in all modes	Defaults switch (SW3) is set	Open switch
14	Can read but cannot set parameters	Front panel Lockout switch (SW1) set	Open switch
15	Instrument beeps continuously when turned On, will not operate	Bad Reset switch	Replace SW6
16	Instrument will not count. High voltage okay, +V1 and +V2 okay.	Bad amplifier component Bad detector Open detector cable PHA switch (SW9) is set and discriminator window is too narrow Bad discriminator component	Check for signal at TP2. If no signal, check Gain adjust and/or replace A2 or Q3. Replace detector Replace cable Check SW9, Recalibrate PHA Replace A2 - A4
17	Instrument does not operate and will not turn off. LED's stay lit.	Processor is 'hung up'	Unplug AC and remove battery fuse to remove processor power, then restore power. Report 'bug' and circumstances to Eberline.

SECTION V
PARTS LIST

The following table lists the electronic items incorporated in the RM-14S and should contain any part necessary for normal repair. Unless otherwise specified, callouts of manufacturers or manufacturers' part numbers are to be considered typical examples only and not restrictions against using equivalent parts with the same operating characteristics. When ordering parts from Eberline, specify model number, serial number, reference designator, value, Eberline part number, or a word description if the part has no reference designation. Eberline will automatically substitute equivalent parts when one called out by the manufacturers' part number is not available.

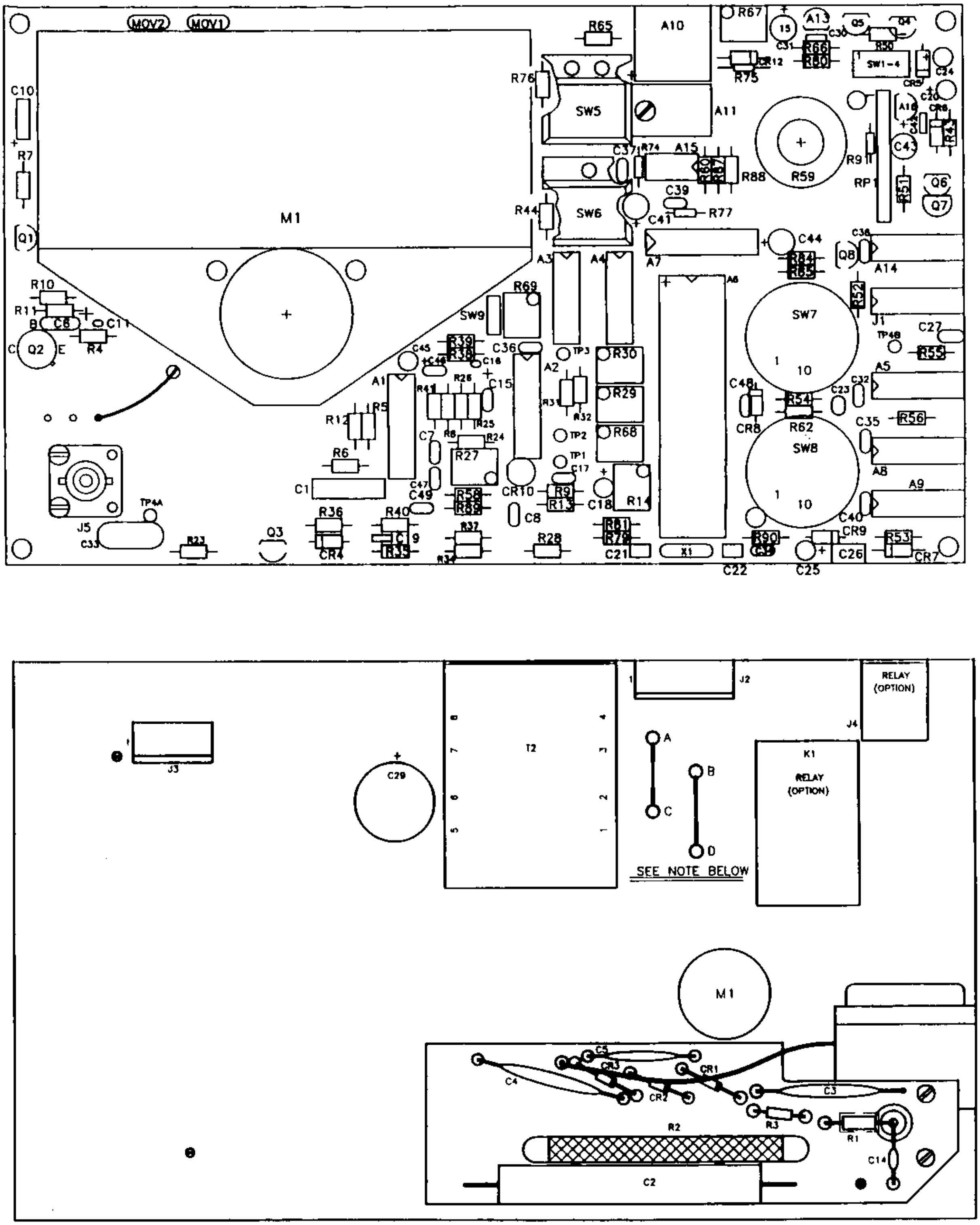
REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
1. Basic RM-14S				
	Bail	5.5" X 2" Bail w/Feet	Buckeye MP41226-20	HDIS1(8)
	Battery	6V Gel-Cel	Globe GC-610-1B	BTGC2(3)
	Chamber	Speaker Chamber		ZP11448013(9)
	Fuse	1/4 Amp, 250V Type 3AG	Littlefuse 312.250	FUST8(5)
	Fuse Drawer	AC Fuse Drawer	Corcom SC1N	COHD73(2)
	Fuse Holder	Battery Fuse Holder	Bussman HTB-32I	FUHO7(6)
	Handle	Black Aluminum	Vemaline EF610	HDHA9(6)
	Hole Plug	Panel Mount Plug	H.H. Smith 3092	MMBZ16(6)
	Knob	Push-On with Pointer	Rogan G-100-P	HDKN26(1)
	Overlay	Front Graphic Panel		ZP11448009(5)
	Powercord	Int'l Style AC Powercord	Belden 17250	WRAC4(4)
	Receptacle	Int'l Style AC Recept.	Corcom 16ESC1D1	COPR13(9)
	Screw	Custom Black Phillips		SCFH0406PB(0)
	Screwdriver	High Voltage Tweeker		VEMI68(4)
	Speaker	2 inch Diameter	Layfayette S-433	ADSP3(6)
2. P.C. Board, part no. YP11448021 (1)				
A1,A2	Integrated Circuit	Dual Op-Amp, Dual Comp.	Motorola MC14575P	ICAOA14575(5)
A3,A5	Integrated Circuit	Dual D Flip-Flop	RCA CD74HC74E	ICHCA74(3)
A4	Integrated Circuit	Quad 2-input NAND Gate	RCA CD74HC00E	ICHCA00(8)
A6	Integrated Circuit	Microcomputer, CMOS	Intel, Mask ROM	ICXXRM14S(9)
A7	Integrated Circuit	D/A Converter, 8-bit	Analog Devices AD7524JN	ICCMA07524(9)
A8,A9	Integrated Circuit	Quad 2-input NOR Gate	RCA CD4001BE	ICCMA4001B(8)
A10	Rectifier	Bridge Rectifier	Varo VS148	CRARVS0148(7)

REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
A11	Integrated Circuit	Regulator, 6V	Motorola MC7806CT	ICAV7806(4)
A13,A16	Integrated Circuit	Regulator, 5V	National LP2950CZ-5.0	ICAVA2950C(9)
A14	Integrated Circuit	Quad Open-Coll. Driver	Sprague UCN-5800A	ICXXA5800A(6)
A15	Integrated Circuit	Dual Op-Amp	T.I. TLC272CP	ICACA272(4)
C1	Capacitor	0.022μF, 80V, 10%	Sprague 192P2239R8	CPPF223P3O(2)
C6	Capacitor	0.27μF, 50V, 20%	Centralab CW30C274K	CPCE274P4N(6)
C7,C8,C15 C17,C32,C34 C35,C36,C37 C38,C39,C40 C46,C47,C48 C49	Capacitor	0.1μF, 50V, 10%	Centralab CW20C104K	CPCE104P3N(7)
C10	Capacitor	0.47μF, 35V, 10% Tantalum	Kemet T110A474K035AS	CPTA474P3L(6)
C11	Capacitor	33μF, 10V, 10% Tantalum	Sprague 199D336X9010DA1	CPXX12(8)
C14,C33	Capacitor	220pF, 3000V, 10%	Centralab DD30-221	CPCE221P3Y(5)
C16	Capacitor	10μF, 16V, 20% Tantalum	Sprague 199D106X0016CB1	CPTA100M4X(3)
C18,C20,C24 C25,C45	Capacitor	1.0μF, 35V, 10% Tantalum	Sprague 199D105X9035AA1	CPXX11(9)
C19,C30,C42	Capacitor	0.01μF, 50V, 20%	Sprague 1C25Z5U473M0508	CPCE473P4N(4)
C21,C22	Capacitor	33pF, 100V, 10% or 20%	Erie CK12BX330K	CPCE330P3P(6)
C23	Capacitor	100pF, 50V	AVX SR151A101KAA	CPCE101P3N(3)
C26	Capacitor	0.022μF, 100V, 10%	Erie CK06BX223K	CPCE223P3P(3)
C27	Capacitor	1000pF, 100V, 10%	Centralab CN20A102K	CPCE102P3P(9)
C29	Capacitor	470μF, 50V, 20%	Sprague 513D477M063EK4	CPAL471M3N(8)
C31,C43	Capacitor	15μF, 20V, 10% Tantalum	Sprague 199D156X9020DA1	CPXX10(0)
C41,C44	Capacitor	39μF, 10V, 10% Tantalum	Sprague 199D396X9010DA1	CPTA390M3F(5)
CR4,5,6,7,9	Diode	Silicon, Switching	1N4148	CRSI1N4148(7)
CR8	Diode	Schottky	1N5711	CRSI1N5711(1)
CR10	LED	High Intensity Red	H/P 5082-4655	OPLP10(3)
CR12	Diode	Silicon, Power	1N4001	CRSI1N4001(3)
J3	Connector	4-pin	Molex 09-60-1041	COMR304(7)

REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
J2	Connector	5-pin	Molex 09-60-1051	COMR305(4)
J5	Connector	PC Mount MHV	Amphenol 27000	CXMH10(9)
M1	Meter	200 microamp		MTPA38(7)
MOV1,MOV2 MEVE33(0)		MOV	Transient Suppress. 130V	GE V130LA1
Q1,Q5,Q8	Transistor	NPN, Silicon	2N4401	TRSN2N4401(6)
Q2	Transistor	PNP, Silicon	Motorola 2N4234	TRSP2N4234(7)
Q3	Transistor	NPN, Silicon	2N5088	TRSN2N5088(3)
Q4	Transistor	PNP, Silicon	2N4403	TRSP2N4403(2)
Q6	Transistor	P-Channel MOSFET	Siliconix VP0300M	TRMPVP0300(7)
Q7	Transistor	N-Channel MOSFET	Siliconix 2N7000	TRMN2N7000(2)
R1,R62	Resistor	100k ohm, 1/4W, 5%		RECC104B22(0)
R3,R88	Resistor	10M ohm, 1/4W, 5%		RECC106B22(5)
R4	Resistor	270 ohm, 1/4W, 5%		RECC271B22(7)
R5	Resistor	1k ohm, 1/4W, 5%		RECC102B22(4)
R6	Resistor	62k ohm, 1/4W, 5%		RECC623B22(9)
R7,R12	Resistor	30k ohm, 1/4W, 5%		RECC303B22(8)
R8	Resistor	100 ohm, 1/4W, 5%		RECC101B22(6)
R9,R56	Resistor	510k ohm, 1/4W, 5%		RECC514B22(0)
R10,R26,R31	Resistor	20k ohm, 1/4W, 1%	RN55D	RECE203B12(0)
R11	Resistor	470 ohm, 1/4W, 5%		RECC471B22(3)
R13	Resistor	43k ohm, 1/4W, 5%		RECC433B22(3)
R14	Potentiometer	50k ohm, 1/4W, 10%	Bourns 3299W-1-503	PTCE503B23(4)
R23,R37	Resistor	2.1k ohm, 1/4W, 1%	RN55D	RECE212B12(1)
R24	Resistor	68.1k ohm, 1/4W, 1%	RN55D	RECE683B12(3)
R25,R40	Resistor	150k ohm, 1/4W, 1%	RN55D	RECE154B12(5)
R27	Potentiometer	100k ohm, 1/4W, 10%	Bourns 3299W-1-104	PTCE104B03(5)
R28	Resistor	1k ohm, 1/4W, 1%	RN55D	RECE102B12(4)
R29,R30 R32,R36	Potentiometer	10k ohm, 1/4W, 10%	Bourns 3299W-1-103	PTCE103B33(1)
R34,R35,R43 R51	Resistor	20k ohm, 1/4W, 5%		RECC203B22(0)
R38,R39,R84	Resistor	200k ohm, 1/4W, 1%	RN55D	RECE204B12(8)
R41	Resistor	5.1k ohm, 1/4W, 5%		RECC512B22(6)
R44,R65	Resistor	680 ohm, 1/4W, 5%		RECC681B22(7)
R50,R81,R89	Resistor	2k ohm, 1/4W, 5%		RECC202B22(2)
R52	Resistor	33k ohm, 1/4W, 5%		RECC333B22(5)
R53	Resistor	75k ohm, 1/4W, 5%		RECC753B22(4)

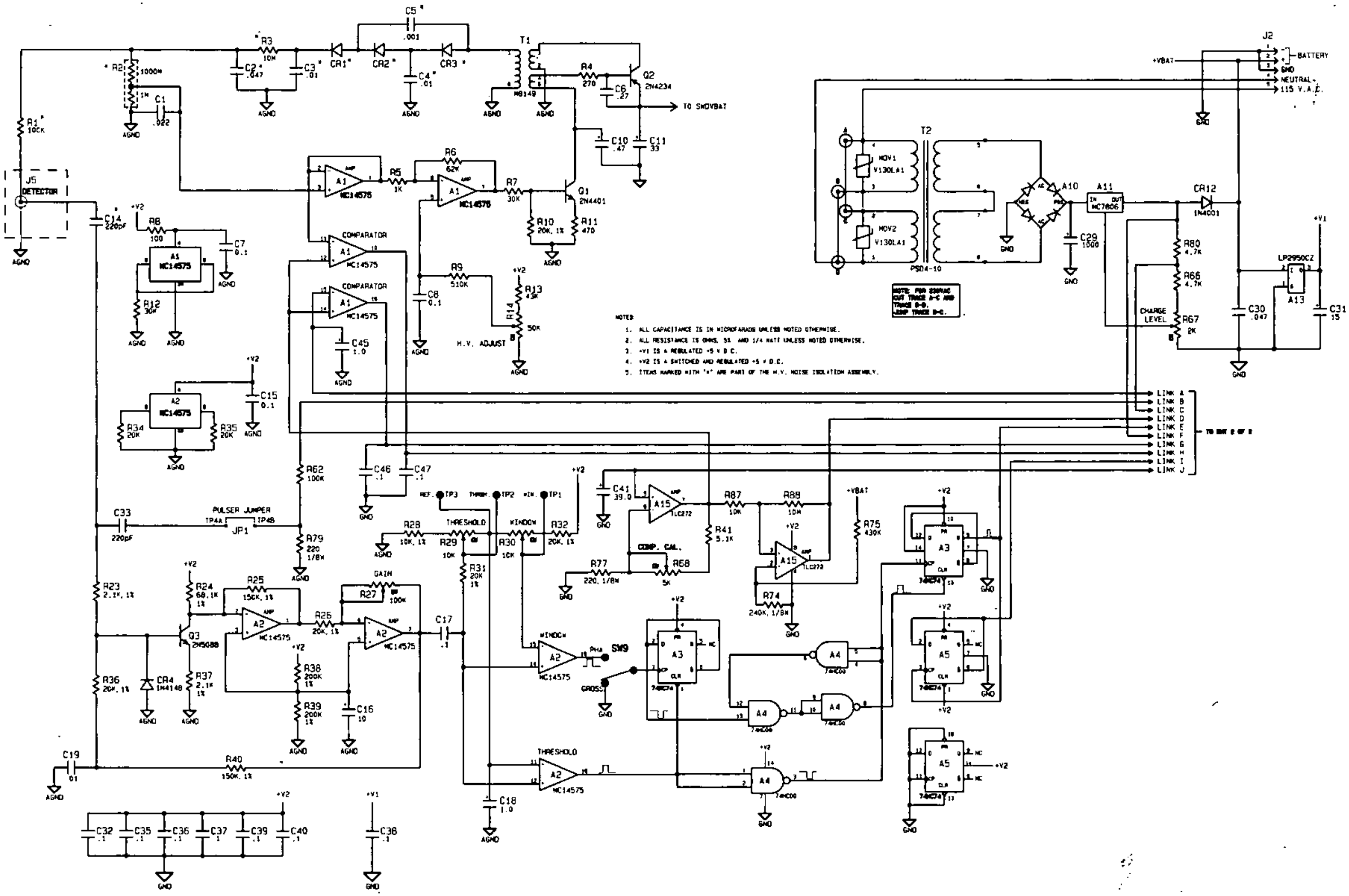
REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
R54	Resistor	5.1M ohm, 1/4W, 5%		RECC515B22(7)
R55	Resistor	270k ohm, 1/4W, 5%		RECC274B22(1)
R58	Resistor	150 ohm, 1/4W, 5%		RECC151B22(1)
R59	Potentiometer	10k ohm, 1/4W, 20%	CTS	PTCC103B63(6)
R60	Resistor	22 ohm, 1/4W, 5%		RECC220B22(4)
R66,R80	Resistor	4.7k ohm, 1/4W, 5%		RECC472B22(1)
R67	Potentiometer	2k ohm, 1/4W, 10%	Bourns 3299W-1-202	PTCE202B33(1)
R68,R69	Potentiometer	5k ohm, 1/4W, 10%	Bourns 3299W-1-502	PTCE502B33(4)
R74	Resistor	240k ohm, 1/8W, 5%		RECC244B21(5)
R75	Resistor	430k ohm, 1/4W, 5%		RECC434B22(1)
R76	Resistor	750 ohm, 1/4W, 5%		RECC751B22(8)
R77,R79	Resistor	220 ohm,1/8 W, 5%		RECC221B21(3)
R85	Resistor	249k ohm, 1/4W, 1%	RN55D	RECE244B12(4)
R87	Resistor	10k ohm, 1/4W, 5%		RECC103B22(2)
R90	Resistor	47k ohm, 1/4W, 5%		RECC473B22(9)
R91	Resistor	100 ohm, 1/8W, 5%		RECC101B21(7)
RP1	Resistor Array	10k ohm, 1/4W, 9 res.	CTS 750-101-R10K	REAR103B21(0)
SW1-4	Switch Array	4-Switch DIP Array	Grayhill 76SB04S	SWMI48(3)
SW-5	Pushbutton	Red Cap w/Grn-Yel LED's	C&K MP01-S2-3-65-C1-BE	SWPB23(2)
SW6	Pushbutton	Black Cap with Green LED	C&K MP01-S1-2-60-C1-BE	SWPB24(1)
SW7,SW8	Rotary Switch	6-Position Rotary Switch	C&K R106-07-RN-02-Q-E	SWRO54(5)
SW9	Slide Switch	Miniature Slide, SPDT	Alcoswitch SSA-12	SWSL8(9)
T1	Transformer	Blocking Oscillator	Microtran M8149	TFHV5(3)
T2	Transformer	230/115V Prim., 10 V Sec.	Triad FS10-600	TFPO38(0)
X1	Crystal	7.3728 MHz, 0.003%	Statek CX-1V-A	CYOS12(5)
	Shield #1			ZP11448037(1)
	Shield #2			ZP11448038(0)
	Faston Receptacle		Amp 61060-1	TEQC2(3)
	Faston Tab		Amp 61134-1	TEQC3(1)

SECRTION VI
DIAGRAMS



NOTE:
FOR 220 V.A.C. OPERATION, CUT TRACE A-C AND TRACE B-D. JUMP TRACE B-C.

Figure 6-1. Component Layout, RM-14S Circuit Board, 11448-D24C

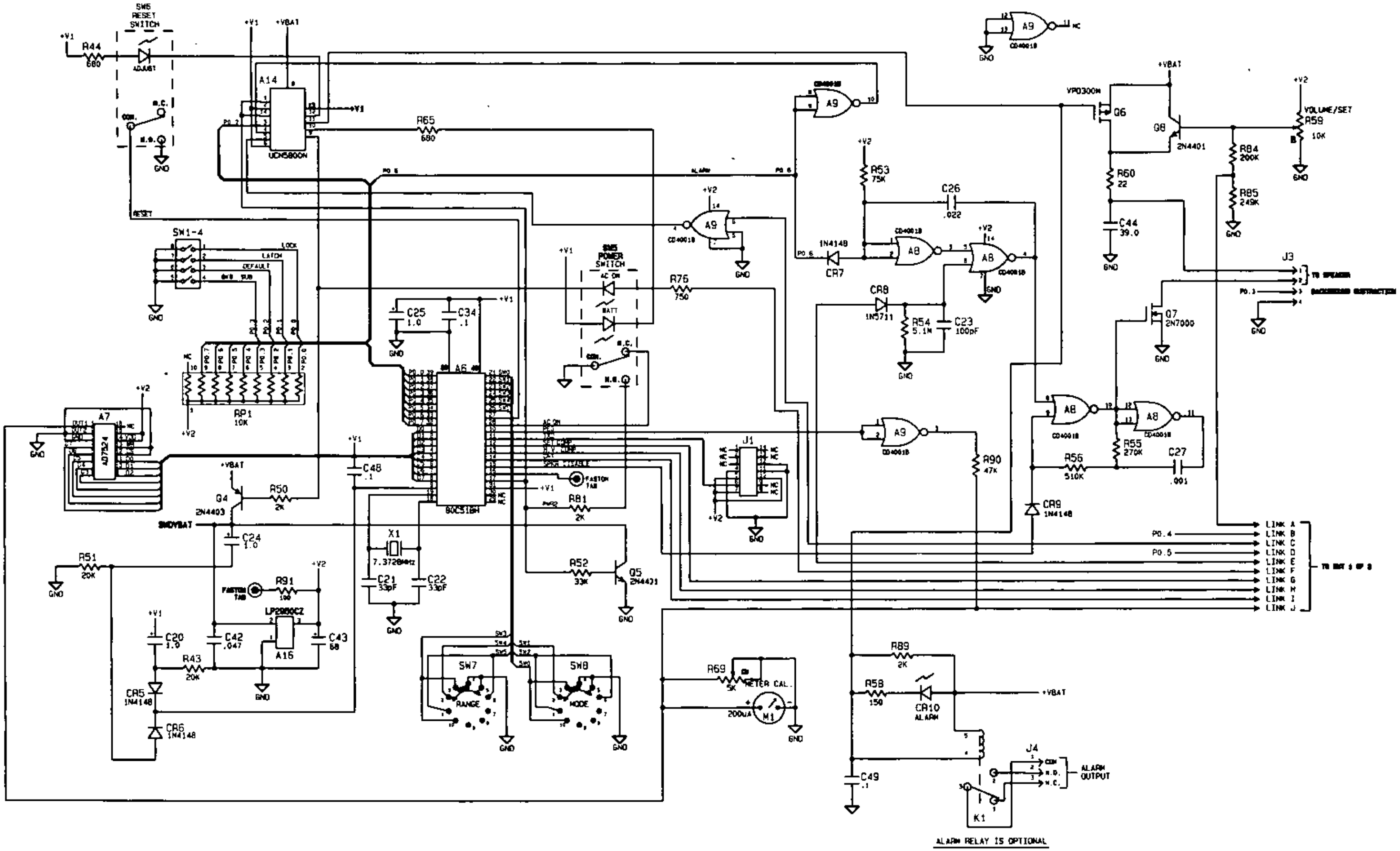


NOTE: FOR 230VAC CUT TRACE A-C AND TRACE B-D. JUMP TRACE B-C.

NOTES:

1. ALL CAPACITANCE IS IN MICROFARADS UNLESS NOTED OTHERWISE.
2. ALL RESISTANCE IS OHMS, 5% AND 1/4 WATT UNLESS NOTED OTHERWISE.
3. +V1 IS A REGULATED +5 V D.C.
4. +V2 IS A SWITCHED AND REGULATED +5 V D.C.
5. ITEMS MARKED WITH "*" ARE PART OF THE H.V. NOISE ISOLATION ASSEMBLY.

Figure 6-2. RM-14S Schematic (11448-D01E, Sheet 1 of 2)



NOTES:

1. ALL CAPACITANCE IS IN MICROFARADS UNLESS NOTED OTHERWISE.
2. ALL RESISTANCE IS OHMS, 5% AND 1/4 WATT UNLESS NOTED OTHERWISE.
3. +V1 IS A REGULATED +5 V.D.C.
4. +V2 IS A SWITCHED AND REGULATED +5 V.D.C.

Figure 6-2. RM-14S Schematic (11448-D01E, Sheet 2 of 2)

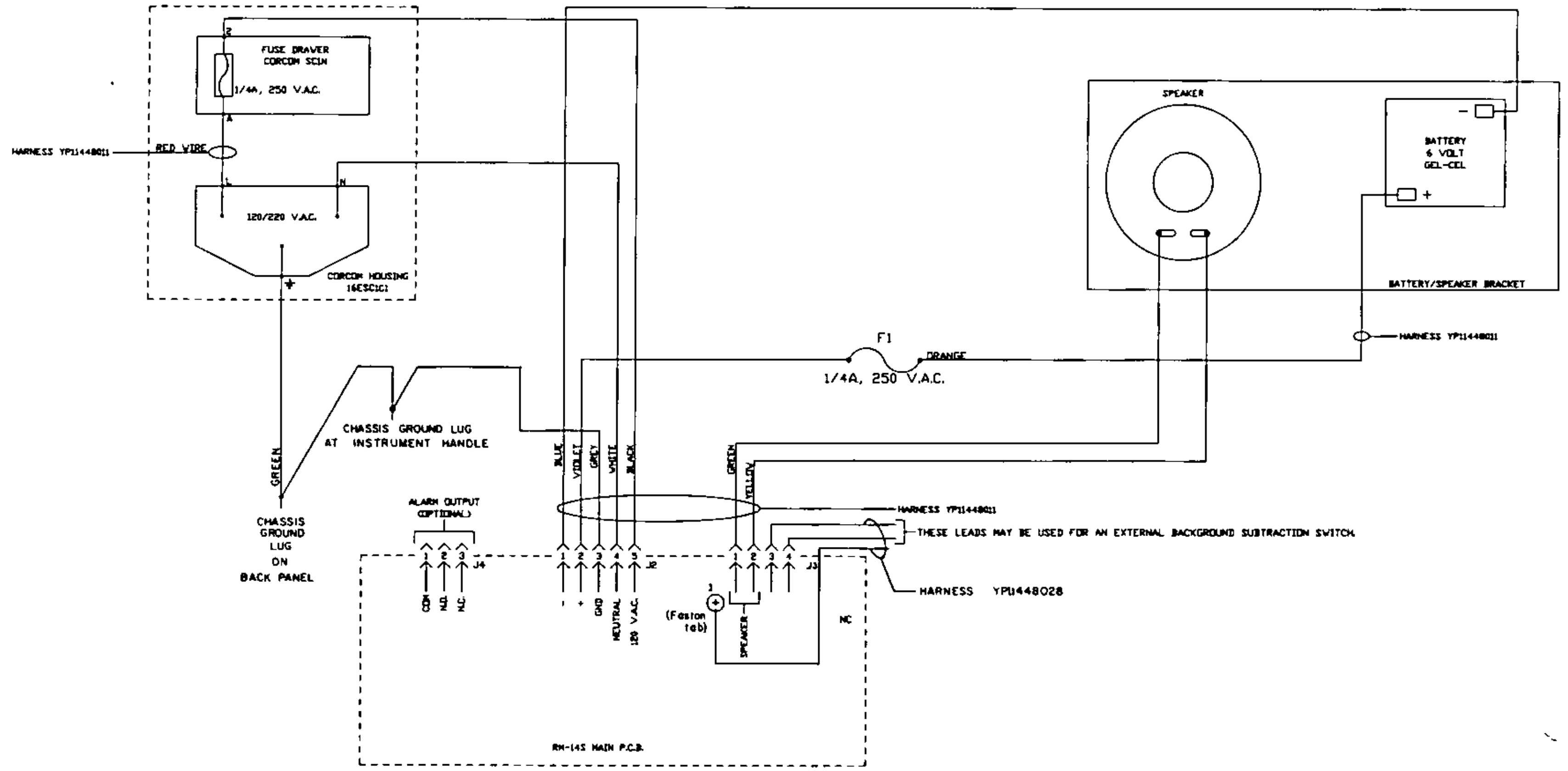


Figure 6-3. RM-14S Wiring Diagram, 11488-C25B

SECTION VII
DETECTORS AND ACCESSORIES

A. OPTIONS

Several options listed below are available on the RM-14S. Other options may be available on a special request basis (please contact an Eberline sales representative).

1. 220 V Operation

The RM-14S may be factory modified for 220 Vac operation. The modification may also be performed by the customer (see Schematic).

- Order RM14S OPT4 (3)

2. Alarm Relay Output

Under this option, 2 amp at 120 Vac, normally-open and normally-closed, terminals are provided for wiring to external devices. The relay closes whenever an alarm occurs.

- Order RM14S OPT1 (6)

3. Set Screw Knobs

This option replaces the standard push-on type front panel knobs with more secure set-screw type knobs for applications where instrument tampering is a problem.

- Order RM14S OPT3 (4)

4. HP-260/270 Probe Holder

This option provides the facility for mounting an Eberline HP-260 or HP-270 probe on the RM-14S.

- Order YP11448016 (8)

5. HP-210 Probe Holder

This option provides the facility for mounting an Eberline HP-210 probe on the RM-14S.

- Order YP11448017 (7)

6. HP-100A Probe Holder

This option provides the facility for mounting an Eberline HP-100A probe on the RM-14S.
- Order YP11448020 (2)

7. RS-232 Test/Calibration Interface

This option provides a cable and interface board for use in performing computer aided test and calibration of an RM-14S. Since the cable can only be connected to the RM-14S with the front panel removed, the customer need not purchase this option for each instrument but may use the same RS-232 test setup for any number of units.

The interface may also be used with a serial printer (see Options 8 and 9 below) as a means of acquiring a printout of test and calibration operations.

- Order RM14S OPT2 (5)
- Order CA70XXFT (3) cable to PC/AT computer (XX is the cable length, in feet) or use a standard 'null-modem'cable

8. Seiko Thermal Printer

The Seiko thermal printer is provided as a standard option with many Eberline instruments and together with the RS-232 Test/Calibration Interface option, provides capability for hardcopy output from an RM-14S. The printer is small, lightweight, battery or line powered, and supports both 40 and 80 column output modes on $4^1/_2$ inch paper rolls.

- Order RCDI15 (6) Seiko Printer
- Order RCCP16 (8) spare thermal printer paper
- Order CA64XX (2) Seiko printer cable

9. Hewlett/Packard ThinkJet Printer

The ThinkJet serial printer is also offered for use with the RM-14S and provides the same capability for hard-copy output from the RM-14S via an RS-232 Test/Calibration Interface. The H/P ThinkJet is a compact, line powered printer, capable of large volume output.

- Order VEHP55 (3) ThinkJet printer
- Order VEHP28 (7) spare ink cartridge
- Order VEHP29 (6) spare paper (2500 sheets/box) or VEHP30 (3) 1000 sheets/box)
- Order CA57XXFT (0) ThinkJet printer cable.

10. Background Subtraction Switch

This option provides a lighted push-button switch on top of the instrument for ease of performing background updates. When lit, the switch indicates the background subtraction value is being updated.

- Order RM14S OPT5 (2).

NO.	MODEL NO.	TYPE	TYPICAL DETECTION	NOMINAL HIGH VOLTS	USEFUL RANGE	BASIC SENSITIVITY CPM PER RATE UNIT	INPUT SENSITIVITY IN mV	DEAD TIME SETTING µS
1	AC-3-7, AC-3-8	Scintillator	Alpha Contamination	1200 V (see note 1)	To 4.2M cpm	1 cpm per cpm	10	6
	HP-100A	Gas Proportional	Alpha and Beta-Gamma	2000 V (see note 1)	To 4.3M cpm	1 cpm per cpm	2	7
2	HP-190A	GM	Beta Contamination	900 V	To 2.7M cpm To 1000 mR/h	1 cpm per cpm 2500 cpm/mR/h	10	255
3	HP-210L, HP-210T, HP-260	GM	Beta Gamma Contamination	900 V	To 5M cpm To 1500 mR/h	1 cpm per cpm 3600 cpm/mR/h	10	55
4	HP-270	GM	Gamma Exposure	900 V	To 4.6M cpm To 3400 mR/h	1 cpm per cpm 1350 cpm/mR/h	10	100
5	HP-290	GM	Gamma Exposure	550 V	To 4.9M cpm To 52 R/h	1 cpm per cpm 93 cpm/mR/h	10	12
6	LEG-1	Scintillator	Low-Energy Gamma or X-ray	1200 V	To 4.5M cpm	1 cpm per cpm	10	8
7	NRD	Proportional Chamber	Neutron Dose Equivalent	2300 V (see note 1)	To 4.7M cpm To 100 rem/h	1 cpm per cpm 45 cpm/mrem/h	2	10
8	SPA-8, 1 X 1 Crystal	Scintillator	Medium Sensitivity Gamma	1000 V (see note 1)	To 4.9M cpm	1 cpm per cpm	10	12
9	SPA-3	Scintillator Sensitivity Gamma	High	1000 V (see note 1)	To 5M cpm To 3.4 mR/h	1 cpm per cpm 1.5M cpm/mR/h	10	16
10	SPA-6	Scintillator	Medium Sensitivity Gamma	1000 V (see note 1)	To 4.9M cpm	1 cpm per cpm	10	12

NOTE 1. Detector voltage should be set as described in the "Maintenance" section of the RM-14S manual.
NOTE 2. Eberline recommends an input sensitivity of 10 mV for all detectors.